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Request for grant of a patent

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1. Your reference	PDG/24867
2. Patent application number *(The Patent Office will fill in this part)*	0220227.3
	~~02SEP02 E744879-1 D02000~~ P01/7700 0.00-0220227.3
3. Full name, address and postcode of the or of each applicant *(underline all surnames)*	XAAR Technology Limited Science Park Cambridge CB4 0XR
Patents ADP number *(if you know it)*	7301872002
If the applicant is a corporate body, give the country/state of its incorporation	United Kingdom
4. Title of the invention	Droplet deposition apparatus
5. Name of your agent *(if you have one)* "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	MATHYS & SQUIRE 100 Gray's Inn Road London WC1X 8AL United Kingdom
Patents ADP number *(if you know it)*	1081001

	Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number			

	Number of earlier application	Date of filing *(day / month / year)*
7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application		

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	YES

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	6
Claim(s)	2
Abstract	
Drawing(s)	1 + 1

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	-

11. I/We request the grant of a patent on the basis of this application.

Signature

Date

MATHYS & SQUIRE 30 August 2002

12. Name and daytime telephone number of person to contact in the United Kingdom

GARRATT, Peter Douglas - 020 7830 0000

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PRINTING METHODS AND INK JET PRINTER

The present invention relates to printing and in particular to ink jet printheads.

There is a demand for digital printers having a printhead, which extends across the full width of the printed page offering high throughput with excellent print quality.

In an ink jet printer of this character, having the necessarily large number of closely spaced ink chambers and nozzles, there will always be a risk of failure of one or more nozzles, whether as a consequence of a manufacturing error or through nozzle blockage or other failures in use.

It will be possible to detect and discard manufactured printheads having even a single failed nozzle. However, because of the very large number of nozzles in each printhead, and because of the sophistication of the manufacturing techniques, such quality control measures would likely lead to an uneconomic manufacturing yield.

In use of the printhead, failure of even a single nozzle can lead to perceptible print artefacts, because of the spatial correlation of the artefact as the printed substrate is indexed past the printhead.

Accordingly, it is an object of the present invention to provide improved methods of printing and improved printheads that are able to conceal artefacts arising from nozzle failures or other departures from standard print performance across a print row.

Accordingly, the present invention consists in one aspect in a method of printing parallel rows of contiguous pixels on a substrate indexed in a direction orthogonal to the rows, comprising the steps of printing for each row of pixels N superimposed rows of contiguous super pixels, each super pixel covering N pixels in the row and each pixel capable of receiving print contributions from N super pixels. Preferable values for N are 2 or 3.

Advantageously, each super-pixel is elongated in the row direction with an aspect ratio of N:1.

Preferably, on detection of a fault in the printability of any super-pixel, the contribution to those pixels covered by that super-pixel is transferred wholly or in part to one or more other super-pixels from which those pixels are capable of receiving print contributions.

Suitably, the desired print density for each pixel is distributed amongst those super-pixels from which the pixel is capable of receiving contributions with this desired print density being greater in certain cases than that achievable by a single super pixel.

In one form of the invention, the distribution serves to compensate for measured differences in the print weight between super-pixels in each row of super-pixels.

In another aspect, the present invention consists in an ink jet printer having a plurality of ink chambers each provided with a nozzle arrangement, the plurality of ink chambers being arranged so as to print on a substrate a row of contiguous print elements, the nozzle arrangement of each ink chamber being such that the print element associated with that ink chamber is elongated in the row direction with an aspect ratio of at least 2:1.

Preferably, at least two sets of ink chambers are provided, each set being arranged so as to print a row of contiguous print elements, the rows of contiguous print elements printed by the respective sets of ink chambers being superimposed.

Advantageously, the print elements of one set of ink chambers is offset in the row direction with respect to the print elements of another set of ink chambers, the offset being preferably the reciprocal of the aspect ratio.

The present invention will now be described by way of example with reference to accompanying drawings in which:-

Figure 1 is a schematic view of an ink jet printhead according to the prior art; and

Figure 2 is a schematic view of an ink jet printer according to the present invention.

Referring initially to Figure 1, an ink jet printhead has a first array of ink chambers 10 defined by a piezoelectric wall structure 12. A nozzle plate 14 secured to the wall structure 12 defines a nozzle for each ink chamber 10. This first array of ink chambers is shown as depositing ink droplets 16 on an appropriate substrate.

Ink jet printheads of this general form are described for example in EP-A-0 277 703 and EP-A-0 278 590.

To increase the number of ink droplets that can be deposited for a unit length of the print row, it has been previously proposed to provide a second array of ink chambers 18 similarly defined by a piezoelectric wall structure 20 and having a nozzle plate 22 defining one nozzle per ink chamber 18. This second array of ink chambers 18 is shown as depositing ink droplets 24 on the substrate. In this way, it is possible effectively to double the print resolution as compared with the "intrinsic" resolution defined by the nozzle spacing in a single array of ink chambers.

Each ink chamber 10 may be formed as an elongate channel, which is collinear with and shares the same ink supply ports, as an elongate channel forming a corresponding one of the ink chambers 18. The parallel array of ink channels is then angled to create the offset in the two sets of nozzles.

If one chamber or nozzle should fail (as marked schematically at X), there will be an unprintable pixel in the print row. Even though the number of ink drops per unit length of the print row may be high (perhaps 360 dpi), a single unprintable pixel may still produce a visually unacceptable artefact because of the spatial correlation of that artefact as the print substrate is indexed relative to the printhead.

This problem is addressed in the printhead according to the invention, which will be described with reference to Figure 2.

A set of print chambers 10 is similarly defined by a piezoelectric wall structure 12. In this case, the nozzle plate 14 serves to define two nozzles per ink chamber 10. Each of the two nozzles is of the same dimension as the single nozzle in the Figure 1 embodiment and the two nozzles of each chamber are arranged to form a single ink drop 30 on the substrate, of double the volume of the ink drop 16 in the Figure 1 embodiment. The chamber structure is modified such that it provides narrower piezoelectric wall

structures 12 and a wider print chamber 10 to allow space for the two nozzles. Each ink drop 30 is elongated in the direction of the print row, having a aspect ratio of 2:1. The.ink drops deposited from a single array of ink chambers 10 are, in this way, contiguous across the print row.

A second set of ink chambers 18 is again defined by a piezoelectric structure 20 with a nozzle plate 22 defining two nozzles per ink chamber 18. These two nozzles combine to form ink drops 32 which similarly have a 2:1 aspect ratio and form a contiguous row.

The ink drops 30 from the first array of ink chambers are offset along the print row with respect to the ink drops 32 of the second set of the chambers 18 by half the pitch of the ink chambers. With this arrangement, if there is a failure of a single chamber such as that shown schematically at X, no pixel remains unprintable.

It is convenient to regard the elongated ink drops 30 and 32 as printing "super-pixels", each pixel of the substrate receiving contributions from up to two super-pixels and each super-pixel covering two pixels. The pixel structure is depicted in Figure 2 as units A, B, C, D of line 40. In the control and drive arrangement for the printhead, provision is made to distribute the desired print density for a particular pixel between the two super-pixels which contribute to that pixel. In a typical arrangement, the desired print density for a pixel - established on a suitable greyscale - would be distributed 50% each to the two corresponding super-pixels. In the event that a failure of an ink chamber (or the associated nozzles) is detected, the distribution of print density can be switched so that each of the two pixels covered by the now missing super-pixel receive 100% of the desired print density from the other super-pixel which covers that pixel. This compensation for a missing super-pixel through variation in the greyscale of neighbouring super-pixels will effect neighbouring pixels. Such effects will generally be far less noticeable than an unprintable pixel. In an improvement, steps are taken to add noise (either by subtracting or adding grey levels) to distribute the effects of the missing lines over 1 or more neighbouring super-pixels and reduce the spatial coherence of the artefact.

Although the row of super-pixels 13 (being the odd-numbered super-pixels 1, 3, 5...) are shown in Figure 2 to be transversely separated from the

row of super-pixels 32 (being the even-numbered super-pixels 2, 4, 6...), this is for drawing convenience only. The two rows of super-pixels are effectively super-imposed.

One approach to deriving the greyscale levels for the super-pixels from the greyscale pixel values received as input print data is as follows.

The greyscale value of each super-pixel is set as one quarter of the sum of the greyscale values for the two pixels covered by the super-pixels, thus:-

$$S_1 = (P_A + P_D)/4$$

$$S_2 = (P_B + P_C)/4$$

This processing will serve as a low-pass spatial filter of the print image. In regions where this spatial filtering may have a noticeable effect on the image, as for example an edge, it will be possible to vary the algorithm or to pre-emphasize the edge so that the filtering has less noticeable effect.

In one embodiment of this invention, a print test is conducted to measure the print rate at each super-pixel for a nominal full black print density. This information is then employed in a calibration process which determines during future use of the printhead how the super-pixel greyscale values S_1, S_2, ... are derived from the input pixel greyscale values P_A, P_B, ...

Thus in a case where the greyscale value of a pixel would be shared 50%-50% between two super-pixels, prior knowledge that one super-pixel is being printed less effectively than another may cause an alternative division to be made. In the case where one super-pixel is not being printed at all, a division 0%-100% can be made. If there is simply a reduction in the printed weight of a super-pixel by reason of some manufacturing variance, a distribution such as 50%; 75% may be suitable.

In an alternative arrangement, a number of super-pixels greater than two may contribute to each pixel. Thus, an arrangement having three arrays of print chambers, with each super-pixel covering three pixels and with each pixel receiving print contributions from three super-pixels, can also be

employed. This arrangement would be expected to increase the resilience to super-pixel failures at the price of increased spatial filtering.

Experiments have shown that with piezoelectric operated ink jet printheads, it is possible to double the number of nozzles in an ink channel with only a modest increase in the actuation voltage required. If necessary, the nozzles formed in the applied nozzle plate may overhang the piezoelectric wall structure to a certain degree without dramatically impairing the operation.

The skilled man will recognize that there are many alternative techniques for printing an elongate super-pixel having an aspect ratio of 2:1, 3:1 or greater.

CLAIMS

1. A method of printing parallel rows of contiguous pixels on a substrate indexed in a direction orthogonal to the rows, comprising the steps of printing for each row of pixels N superimposed rows of contiguous super pixels, each super pixel covering N pixels in the row and each pixel capable of receiving print contributions from N super pixels.

2. A method according to Claim 1, wherein each super-pixel is elongated in the row direction with an aspect ratio of N:1.

3. A method according to Claim 1 or Claim 2, wherein N = 2 or 3.

4. A method according to any one of the preceding claims, wherein on detection of a fault in the printability of any super-pixel, the contribution to those pixels covered by that super-pixel is transferred wholly or in part to one or more other super-pixels from which those pixels are capable of receiving print contributions.

5. A method according to any one of the preceding claims, wherein the desired print density for each pixel is distributed amongst those super-pixels from which the pixel is capable of receiving contributions.

6. A method according to Claim 5, wherein said desired print density is greater than that achievable by a single super pixel.

7. A method according to Claim 5 or Claim 6, wherein said distribution serves to compensate for measured differences in the print weight between super-pixels in each row of super-pixels.

8. A method according to Claim 5 or Claim 6, wherein the print weight of each contributing super pixel is between 0% and 100% of said desired print density.

9. An ink jet printer having a plurality of ink chambers each provided with a nozzle arrangement, the plurality of ink chambers being arranged so as to print on a substrate a row of contiguous print elements, the nozzle arrangement of each ink chamber being such that the print element associated with that ink chamber is elongated in the row direction with an aspect ratio of at least 2:1.

10. An ink jet printer according to Claim 9, wherein at least two sets of ink chambers are provided, each set being arranged so as to print a row of contiguous print elements, the rows of contiguous print elements printed by the respective sets of ink chambers being superimposed.

11. An ink jet printer according to Claim 9 or Claim 10, wherein the print elements of one set of ink chambers is offset in the row direction with respect to the print elements of another set of ink chambers.

12. An ink jet printer according to Claim 11, wherein the offset is the reciprocal of the aspect ratio.

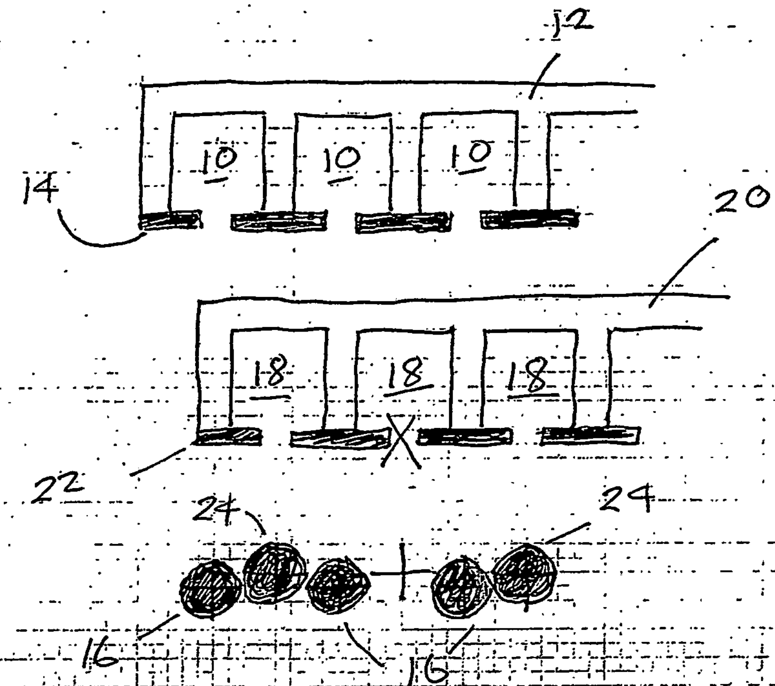

FIGURE 1

PRIOR ART

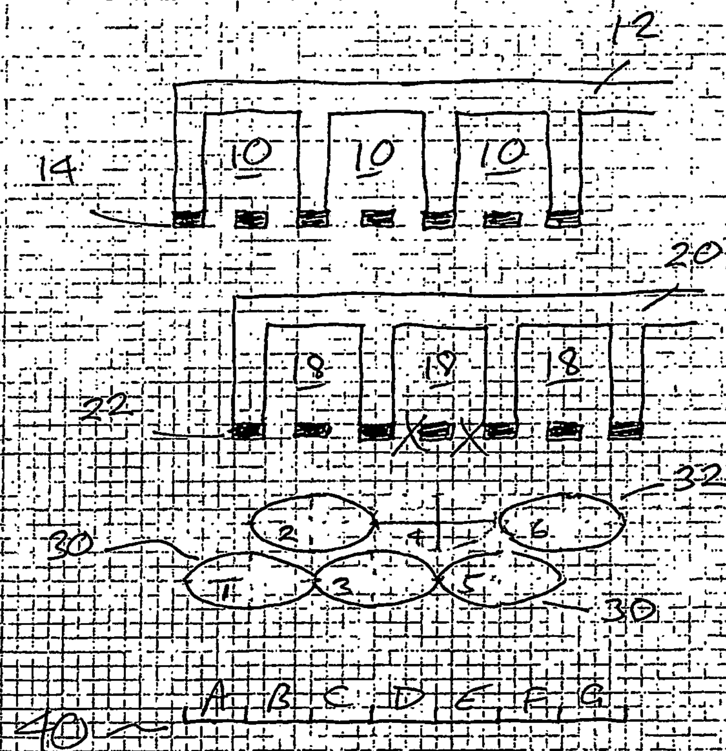

FIGURE 2

PCT Application
GB0303767